

# Changes in Ankle Joint Proprioception Resulting From Strips of Athletic Tape Applied Over the Skin

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**Objective:** In part, the believed effectiveness of taping in preventing injuries may be in the increased proprioception that it provides through stimulation of cutaneous mechanoreceptors. The objective of this study was to examine the effectiveness of strips of athletic tape applied over the skin of the ankle in improving ankle joint movement and position perception.

**Design and Setting:** The study consisted of a single-group, repeated-measures design, where all subjects were tested under all conditions presented in a fully randomized order. Testing was performed in the biomechanics laboratory at Marquette University.

**Subjects:** Twenty healthy males (mean age =  $20.3 \pm 1.5$  yr) participated in this study.

**Measurements:** Ankle joint movement and position perception for plantar flexion and dorsiflexion were tested using a specially designed apparatus. Each individual was tested with and without two 12.7-cm (5-inch) strips of tape applied in a distal-proximal direction directly to the skin in front of and behind the subject's talocrural joint.

**Results:** Data were analyzed with repeated-measures analyses of variance (ANOVA) models. Our results indicate that under the nonweightbearing condition, taping significantly improved ( $p < .05$ ) the ability of the subjects to perceive ankle joint position, especially for a  $10^\circ$  plantar-flexed position. In the weightbearing condition, the use of tape did not significantly alter ( $p > .05$ ) the ability of the subjects to perceive ankle position. Similarly, taping did not alter ankle movement perception in either the weightbearing or nonweightbearing condition ( $p > .05$ ).

**Conclusions:** We concluded that increased cutaneous sensory feedback provided by strips of athletic tape applied across the ankle joint of healthy individuals can help improve ankle joint position perception in nonweightbearing, especially for a midrange plantar-flexed ankle position.

**Key words:** external support, kinesthesia, joint position perception, joint movement perception

Athletic trainers, physical therapists, and other rehabilitation professionals stress the importance of proprioceptive reeducation during the rehabilitation process following an injury.<sup>1, 2</sup> It is believed that an injury such as an inversion ankle sprain, for example, results in a reduction of proprioceptive function that may lead to future reinjuries.<sup>3</sup> One suggested palliative method to supplement a deficit in proprioceptive function at the ankle is the use of external support such as taping and braces.<sup>4-7</sup> The tape or brace is believed to provide increased mechanical support as well as increased proprioception.

While a few studies have investigated the effects of taping and bracing on tasks such as maintaining standing balance,<sup>5-8</sup> no study has directly measured the effects of taping on ankle joint position and movement perception. This lack of information is partly due to the current limited ability to directly assess these aspects of proprioception at the ankle joint.

The purpose of this study was to examine the effects of strips of athletic tape, applied over the skin of the ankle, on a person's ability to perceive joint movement and joint position at the ankle. An apparatus specially designed for the purpose of measuring joint position sense and kinesthesia (joint movement

perception) at the ankle was used.<sup>9</sup> It was hypothesized that ankle proprioception would be improved with the added cutaneous sensory stimuli provided with the use of athletic tape.

## METHODS

### Subjects

Twenty healthy males between the ages of 19 and 25 (mean age =  $20.3 \pm 1.5$  yr) participated in this study. All subjects were free of current or chronic ankle injuries and had normal ligamentous stability of the ankle. The subjects were recruited from the general student population of Marquette University through media frequently read by this group—fliers, advertisement boards, and student newspapers. An informed consent, approved by the Marquette University Institutional Review Board, was obtained from each subject prior to his participation in the study.

Baseline data for basic physical characteristics were collected on each subject. These included age, weight, height, and range of motion at the ankle for plantar flexion and dorsiflexion. Standard clinical stability testing of the ankle ligamentous structures was performed in order to rule out anterior and lateral talocrural joint instability. Subjects were also screened for any significant ankle/foot deformity (such as excessive foot

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planus and foot cavus), any recent (within 6 months) ankle injuries, any history of chronic ankle sprains, and any history of significant injury at the ankle.

## Testing Apparatus

The ankle joint movement and position perception apparatus, which was designed to objectively measure various aspects of ankle proprioception, consisted of two individually movable foot platforms (Fig 1). Each platform was made up of a 12-by-7-inch metal plate, on which the subject placed his foot, and two 9-inch-high side walls. These side walls are used to provide an attachment base for the axes connecting the foot platforms to the supporting uprights. The distance between the axis of rotation of each platform and the surface on which the subject stood was adjustable from 0 to 6 inches. This "depth" adjustment, made by varying the thickness of the floor layers (wood plates) between the foot and the platform itself, was an important feature in properly matching the axis of rotation of the platform with the lateral malleolus (the lateral malleolus corresponds to the approximate location of the axis of rotation of the ankle for plantar flexion and dorsiflexion). An electrically driven electromagnetic actuator was used to move each platform individually at angular velocities varying from 0.1 to 4.0°/sec. Lengthening of the actuator caused an upward tilt of the anterior section of the foot platform, which brought the ankle in dorsiflexion; shortening of the actuator caused a downward tilt of the platform and resulted in ankle plantar flexion. A total amplitude of angular movement of 25° (8° upward and 17° downward) could be achieved with the

actuator. An inclinometer, precise to 0.01 degree, was directly mounted on each foot platform to measure the angular position of each ankle. To eliminate lower leg movement, the subject's lower legs were fixed to a shin pad using two VELCRO® pads (Fig 1). A surrounding wood platform was built to make the apparatus more accessible and to allow for testing with the subject sitting. This platform included a surrounding rail that the subject could hold to further stabilize the upper body. This rail, combined with the anatomical placement of the platform's axis of rotation, ensured that the shin pad and VELCRO straps provided similar stability for the sitting and standing testing positions, standardizing the testing procedures across all conditions. Test-retest reliability of this device for the testing of joint movement perception was established at  $r = 0.84$ .<sup>9</sup> Further description of the device has been published elsewhere.<sup>9</sup>

## Testing Protocol for Ankle Proprioception

For each subject, testing was performed on either the right or left ankle. The choice of the ankle to be tested was made by the principal investigator based on the exclusion criteria listed earlier in Methods. In cases where both ankles were suitable for testing, the right ankle was tested. Two aspects of proprioception at the ankle were tested: joint position perception (JPP) and joint movement perception threshold (JMPT). JPP was tested by evaluating the ability of the subject to return the ankle joint to a predetermined angular position. The difference (in degrees) between the predetermined angular position of the ankle and the position to which the subject returned the ankle was considered a measure of ankle JPP. JMPT was tested by evaluating the ability of the subject to perceive angular movement at the ankle. This characteristic was measured by the amount of passive angular movement necessary at the ankle before the subject was able to correctly state the direction of the movement (either plantar flexion or dorsiflexion).

Both JPP and JMPT were measured in a weightbearing, as well as in a relatively nonweightbearing, condition. The weightbearing condition (similar to closed kinetic chain activities) was achieved by having the subject tested while standing on the apparatus (Fig 1). The relatively nonweightbearing condition (similar to open kinetic chain activities) was achieved by having the subject tested while sitting in a chair with both feet resting on the platforms (Fig 2). Although we defined this condition as being nonweightbearing, minimal weight was actually applied under the foot, secondary to the contact with the foot platform.

For all aspects of the study, a balanced, randomized design was used, eliminating testing bias due to systematic testing sequences. To achieve randomization, standard latin square tables were used. Testing was performed on two different days, no more than three days apart. JPP was tested during the first test day; JMPT was tested during the second test day.

## JPP Testing

To test JPP, the tester used the linear actuator to passively place the subject's ankle in a predetermined 10° plantar-flexed

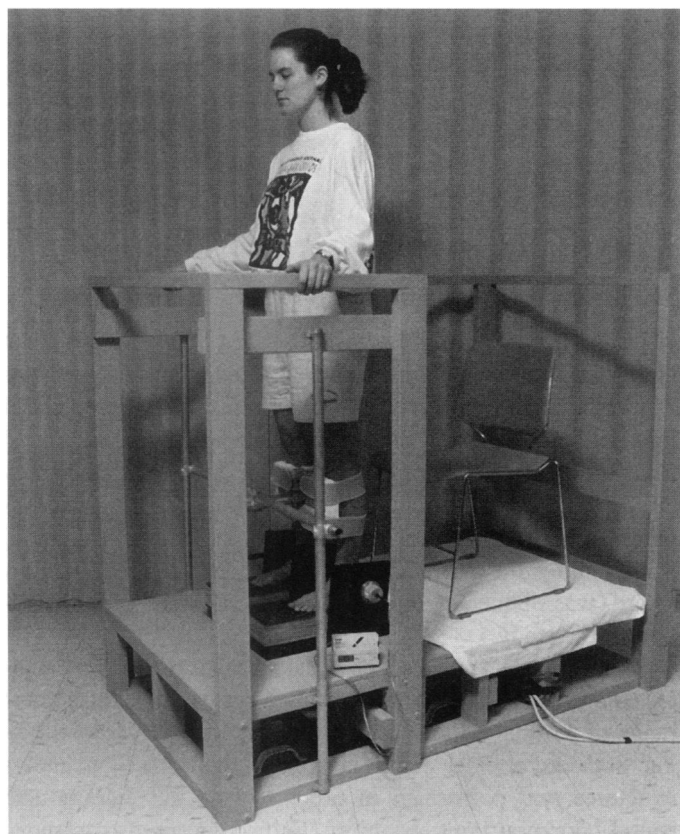
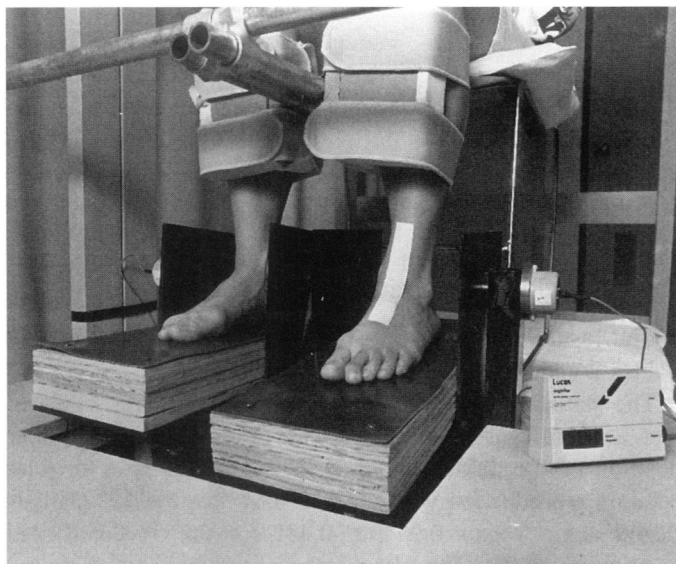


Fig 1. Individual being tested standing on the ankle device.



**Fig 2. Tape applied to the anterior aspect of the ankle.**

or 5° dorsiflexed angular position for 5 seconds. After the subject was told that this was the position he should aim to reproduce, the ankle was returned (by the tester) to a standard neutral position (defined as the foot parallel to the ground while the lower leg was in the vertical plane). After a period of 3 seconds in the neutral position, the subject was asked to provide the necessary instructions to the tester in order to return the ankle to the predetermined position; the tester passively moved the ankle using the actuator. This testing sequence was repeated for each trial. The subject was tested three times in a row for the 10° plantar-flexed position and three times in a row for the 5° dorsiflexed position. The errors made for each of the three trials were averaged for each direction to obtain one error value for the plantar-flexed position and one error value for the dorsiflexed position. The order of presentation of the angles was randomized across subjects. JPP for the ankle was measured for the following conditions: (1) weightbearing without tape, (2) nonweightbearing without tape, (3) weightbearing with tape, and (4) non-weightbearing with tape.

### JMPT testing

To test JMPT, the ankle was passively moved from the predefined standard neutral position (defined as the foot parallel to the ground while the lower leg was in the vertical plane) in either dorsiflexion or plantar flexion at an angular velocity of 0.25°/sec. During testing, the subject held a stop button that allowed him to stop the movement of the platform at any time. The task of the subject was to use the stop button to stop the platform as soon as he was able to determine the direction of movement of his ankle.

To eliminate guessing and/or anticipation from the subject, a variable amount of time was used between indicating to the subject the start of the test and initiating movement of the foot platform. In addition, noise coming from the actuator was masked through the use of white noise heard over a set of headphones worn by the subject. Finally, to further eliminate

guessing, the subject was instructed that the examiner would from time to time activate the opposite foot platform instead of the platform of the ankle being tested. Between trials, the foot platform was returned to its neutral position, as described earlier. The JMPT was determined by the difference between the angular position when the movement of the platform was initiated and the position of the platform when the platform was stopped by the subject. The sequence of presentation for direction of movement (plantar flexion or dorsiflexion) was randomized.

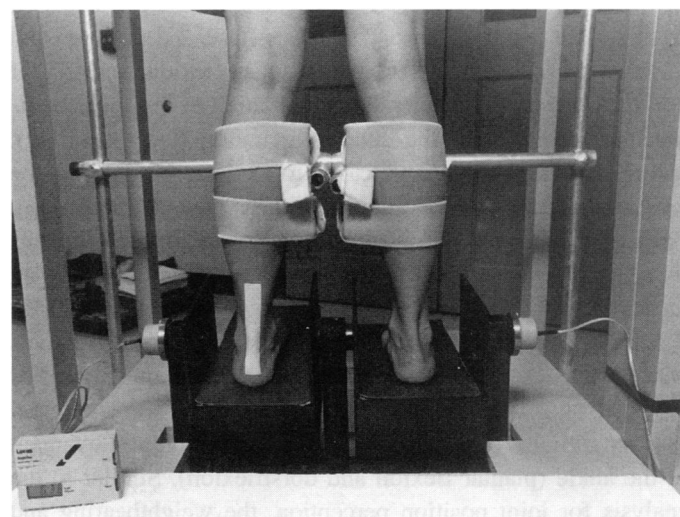
Testing was performed for dorsiflexion and plantar flexion during weightbearing and nonweightbearing with and without tape. Three trials were performed for each direction for each condition. The results of the three trials were averaged and recorded as the JMPT.

In this study, we used a very slow angular velocity in order to minimize, as a factor in the measurement of JMPT, the reaction time between the perception of movement and the pressing of the stop button by the subject. The angular velocity used for testing was slower than the 0.5°/sec angular velocity used by Lephart et al<sup>10</sup> for testing joint movement perception at the knee, but our earlier work with the ankle apparatus showed that no statistically significant difference existed between testing performed at 0.25°/sec as compared with 0.75°/sec.<sup>9</sup>

### Taping

In this experiment, two 12.7-cm-long (5-inch-long) strips of athletic tape were used to add cutaneous sensory stimulus at the ankle. One strip, starting approximately 7.6 cm proximal to the ankle joint line and ending 5.1 cm distal to the ankle joint line, was positioned directly on the skin over the anterior aspect of the ankle joint (Fig 2). A similar strip was used posteriorly over the Achilles tendon and calcaneus (Fig 3). Any hair in the area where the tape was to be applied was shaved prior to the application of the tape.

These strips of tape were used to selectively add cutaneous sensory feedback around the ankle. This model was preferred



**Fig 3. Tape applied to the posterior aspect of the ankle.**

to directly taping the ankle because we were interested in specifically examining the role of added cutaneous stimulation of the athletic tape without the added mechanical constriction and pressure associated with the application of ankle taping as used in athletic events. Although this model may not directly answer the question of whether taping increases proprioception at the ankle, it provides a better generalization of our findings in terms of the role of added cutaneous stimulation on joint proprioception.

## Subjective Questionnaire

After the JPP testing session, each subject was asked the following three questions regarding his ability to reproduce a given angle: (1) Did the tape help you bring your ankle back to the desired position? (2) Was testing easier while standing (weightbearing) or while sitting (nonweightbearing)? (3) Was testing easier with the foot up (dorsiflexion) or the foot down (plantar flexion)?

After the JMPT testing session, each subject was asked to answer the following three questions regarding his ability to perceive movement at the ankle: (1) Did the tape help you with the perception of movement at the ankle? (2) Was testing easier while standing (weightbearing) or while sitting (nonweightbearing)? (3) Was testing easier with the foot going up (dorsiflexion) or the foot going down (plantar flexion)?

## Statistical Analysis

Data analysis was performed with the SPSS statistical software package (SPSS, Inc, Chicago, IL) on Marquette University's mainframe computer. The primary focus of the data analysis was to determine the influence of tape on joint position and joint movement perception. Therefore, separate ANOVA models were used to analyze the weightbearing and nonweightbearing conditions independently.

Data analysis for JPP was performed using two  $2 \times 2$  two-way ANOVA models for repeated measures. The two factors were external sensory stimulus (tape and no tape) and position of the ankle ( $10^\circ$  of plantar flexion and  $5^\circ$  of dorsiflexion). One model was used to analyze the four conditions performed with the subjects standing (weightbearing), and a separate ANOVA was used to analyze the data for the four conditions with the subjects sitting (nonweightbearing). Each ANOVA was followed by a least squares (LS) means post hoc analysis to identify any significant differences among means.

Similar two-way ANOVA models, followed by LS means post hoc analyses, were used to analyze the data on JMPT. For the analysis of JMPT data, the two factors were external sensory stimulus (tape and no tape) and direction of movement of the ankle (plantar flexion and dorsiflexion). Similar to the analysis for joint position perception, the weightbearing and nonweightbearing conditions were analyzed separately.

## RESULTS

### Descriptive Data

Twenty males between the ages of 19 and 25 participated in the study. The descriptive statistics on the group are provided in Table 1.

### Joint Position Perception

The results of the testing for ankle JPP are presented in Tables 2 and 3.

The statistical analysis for JPP in weightbearing indicated that a significant main effect was present for the angular position of the ankle (Table 3). The average error in joint position reproduction was  $1.50^\circ \pm 0.64^\circ$  for the  $10^\circ$  plantar-flexed ankle versus  $0.94^\circ \pm 0.43^\circ$  for the  $5^\circ$  dorsiflexed position ( $p < .01$ ). Therefore, better accuracy in returning the ankle to the desired position was demonstrated for the dorsiflexed position. The ability to reproduce ankle position with tape versus without tape was  $1.13^\circ \pm 0.54^\circ$  and  $1.31^\circ \pm 0.67^\circ$ , respectively. This difference was not statistically significant ( $p > .05$ ). No significant interactions existed between the two factors.

For the nonweightbearing conditions, significant main effects were found for both factors in the model: angular position of the ankle and tape ( $p < .01$ ) (Table 3). Post hoc analysis of the data indicated a significant interaction between tape and angular position ( $p < .05$ ), with the use of tape significantly improving the ability of the subjects to perceive ankle joint position only for the plantar-flexed position. For the  $10^\circ$  of plantar flexion position, an average error of  $1.53^\circ \pm 0.84^\circ$  was made with the use of tape as compared with a mean error of  $2.31^\circ \pm 1.22^\circ$  without the use of tape (Table 2). The same comparison made for the  $5^\circ$  of dorsiflexion position indicated that the average error with tape was  $1.08^\circ \pm 0.59^\circ$  as compared with  $1.12^\circ \pm 0.62^\circ$  without tape.

The results for JMPT are presented in Tables 4 and 5. The statistical analysis for JMPT in weightbearing indicated that a significant main effect existed for the direction of movement of the ankle ( $p < .05$ ) (Table 5). The mean amount of angular movement necessary before detection of plantar flexion was  $0.60^\circ \pm 0.47^\circ$  vs  $0.67^\circ \pm 0.50^\circ$  for the detection of movement toward dorsiflexion.

**Table 1. Subject Characteristics ( $n = 20$ )**

Variables	Mean $\pm$ SD	(Range)
Age (yr)	$20.3 \pm 1.5$	(19.0–25.0)
Height (cm)	$179 \pm 6$	(163–191)
Weight (kg)	$74.2 \pm 8.3$	(58.5–87.1)
Ankle PROM PF (degrees)*	$36.9 \pm 8.2$	(25.0–57.0)
Ankle PROM DF knee bent (degrees)†	$17.8 \pm 5.4$	(6.0–27.0)
Ankle PROM DF knee extended (degrees)‡	$9.2 \pm 3.1$	(5.0–16.0)

\* Amount of passive range of motion (PROM) of the ankle for plantar flexion (PF).

† Amount of passive range of motion of the ankle for dorsiflexion (DF) measured with the knee bent at approximately  $90^\circ$  of flexion.

‡ Amount of passive range of motion of the ankle for dorsiflexion measured with the knee fully extended.

**Table 2. Ankle joint position perception (in degrees)\***

Conditions	Mean $\pm$ SD	(Range)
Weightbearing		
No tape/plantar flexion	1.64 $\pm$ 0.65	(0.47–3.47)
Tape/plantar flexion	1.36 $\pm$ 0.62	(0.21–2.75)
No tape/dorsiflexion	0.98 $\pm$ 0.52	(0.37–2.37)
Tape/dorsiflexion	0.90 $\pm$ 0.31	(0.42–1.70)
Nonweightbearing		
No tape/plantar flexion	2.31 $\pm$ 1.22	(0.53–4.87)
Tape/plantar flexion	1.53 $\pm$ 0.84	(0.30–3.22)
No tape/dorsiflexion	1.12 $\pm$ 0.62	(0.41–2.27)
Tape/dorsiflexion	1.08 $\pm$ 0.59	(0.36–3.15)

\* These values represent the amount of error in trying to reproduce a predetermined ankle angular position. Therefore, the closer the value is to 0.00, the better the performance.

**Table 3. ANOVA results for ankle joint position perception**

Conditions	Mean $\pm$ SD (Degrees)	DF*	F value	p-value
Weightbearing				
Tape	1.13 $\pm$ 0.54	1	2.56	0.13
No tape	1.31 $\pm$ 0.67			
Dorsiflexion	0.94 $\pm$ 0.43	1	36.46	0.00
Plantar flexion	1.50 $\pm$ 0.64			
Nonweightbearing				
Tape	1.30 $\pm$ 0.76	1	9.08	0.01
No tape	1.72 $\pm$ 1.13			
Dorsiflexion	1.10 $\pm$ 0.60	1	13.56	0.00
Plantar flexion	1.92 $\pm$ 1.11			

\* DF, degrees of freedom.

**Table 4. Ankle joint movement perception (in degrees)\***

Conditions	Mean $\pm$ SD	(Range)
Weightbearing		
No tape/plantar flexion	0.56 $\pm$ 0.38	(0.20–1.67)
Tape/plantar flexion	0.64 $\pm$ 0.55	(0.19–2.64)
No tape/dorsiflexion	0.70 $\pm$ 0.60	(0.22–2.91)
Tape/dorsiflexion	0.65 $\pm$ 0.39	(0.27–1.92)
Nonweightbearing		
No tape/plantar flexion	0.73 $\pm$ 0.57	(0.24–2.36)
Tape/plantar flexion	0.82 $\pm$ 0.58	(0.15–2.85)
No tape/dorsiflexion	0.98 $\pm$ 0.73	(0.32–2.93)
Tape/dorsiflexion	0.89 $\pm$ 0.62	(0.27–3.15)

\* These values represent the amount of angular displacement that took place at the ankle before the subject was able to perceive the movement. Therefore, the closer the value is to 0.00, the better the performance.

Under the nonweightbearing conditions, there was also a statistically significant difference in the ability to perceive the direction of movement at the ankle ( $p < .05$ ) (Table 5). The average amount of angular movement necessary before detection of plantar flexion was  $0.78^\circ \pm 0.57^\circ$  vs  $0.93^\circ \pm 0.67^\circ$  for the detection of movement toward dorsiflexion.

The use of tape did not significantly alter ( $p > .05$ ) the ability of the subjects to perceive movement at the ankle under any of the conditions (Table 5).

**Table 5. ANOVA results for ankle joint movement perception**

Conditions	Mean $\pm$ SD (Degrees)	DF*	F-value	p-value
Weightbearing				
Tape	0.65 $\pm$ 0.47	1	0.00	0.99
No tape	0.63 $\pm$ 0.50			
Dorsiflexion	0.67 $\pm$ 0.50	1	6.09	0.02
Plantar flexion	0.60 $\pm$ 0.47			
Nonweightbearing				
Tape	0.86 $\pm$ 0.60	1	0.14	0.72
No tape	0.86 $\pm$ 0.66			
Dorsiflexion	0.93 $\pm$ 0.67	1	5.21	0.03
Plantar flexion	0.78 $\pm$ 0.57			

\* DF, degrees of freedom.

## Subjective Questionnaire

As seen in Table 6, the above findings were corroborated by the subjective opinion of the subjects. When asked, 16 of 20 subjects stated that the tape helped with position perception, while only 5 of 18 subjects stated that the tape helped with movement perception. Data were available on only 18 of the 20 subjects for joint movement perception because two subjects failed to complete this part of the questionnaire.

## DISCUSSION

The ankle is one of the most common sites of injury in sports, with ankle sprains accounting for 85% of all ankle injuries.<sup>11–13</sup> It is estimated that 70% of all high school basketball players have a history of an ankle sprain, with an 80% recurrence rate.<sup>13</sup> The high rate of injury and especially reinjury seen with ankle sprains has challenged the clinical community to provide better rehabilitative as well as prophylactic strategies to reduce the incidence rate. Methods traditionally used to prevent ankle sprains include strengthening programs, proprioceptive training, and the use of external support such as braces and athletic tape.<sup>14–16</sup>

Many clinicians believe that bracing and taping provide increased cutaneous stimuli as well as external support to the joint that they surround. The increased stimulation of the cutaneous proprioceptors, provided through direct or indirect contact between the skin and the brace or tape, would enhance kinesthetic and joint position sense awareness and possibly help prevent injuries. To date, only scarce scientific evidence can be presented to support the fact that proprioceptive feedback at the ankle is improved by the use of bracing or taping.<sup>4,17</sup>

The most common method used to assess the effect of taping or bracing on proprioception at the ankle has been through the evaluation of balance and postural control.<sup>5–8</sup> Overall, these studies have failed to show that athletic tape or ankle braces resulted in better balance or an improved ability to maintain a static posture.<sup>5–8,18,19</sup> In fact, a few of these authors have actually provided evidence that the use of tape or brace may decrease the ability to perform a balance task.<sup>5,7,8</sup> This decreased ability to maintain a static posture was partially attributed to the limitation of joint movement that may occur with the use of external support.<sup>8</sup> Despite the fact that

**Table 6. Subjective questionnaire**

Variables	Responses		
Joint position perception			
Did the tape help you bring your ankle back to the desired position?	16 (yes)	3 (no)	1 (hindered)
Was testing easier while standing (weightbearing—WB) or while sitting (nonweightbearing—NWB)?	12 (WB)	4 (NWB)	4 (no difference)
Was testing easier with the foot up (dorsiflexion) or the foot down (plantar flexion)?	6 (up)	6 (down)	8 (no difference)
Joint movement perception*			
Did the tape help you with the perception of movement at the ankle?	5 (yes)	13 (no)	
Was testing easier while standing (weightbearing—WB) or while sitting (nonweightbearing—NWB)?	10 (WB)	4 (NWB)	4 (no difference)
Was testing easier with the foot going up (dorsiflexion) or the foot going down (plantar flexion)?	6 (up)	6 (down)	6 (no difference)

\* Eighteen of the 20 subjects completed this questionnaire.

maintaining posture is recognized as a task requiring proprioceptive feedback of the ankle, it also involves vestibular and visual sensory function.<sup>20</sup> The degree of redundancy among these systems<sup>20</sup> makes the interpretation of changes in postural control difficult in regard to the effects of taping or bracing on ankle joint proprioception. Therefore, the above studies may not be optimal in establishing the effect of tape on proprioception.

A few authors have specifically investigated the effects of taping or bracing on joint movement or position perception at the ankle. In order to assess the effects of a rigid ankle orthosis on joint position perception at the ankle, Feuerbach et al<sup>17</sup> used a three-dimensional video analysis system. The subjects were asked to reproduce nine predetermined angular positions of the ankle with and without the use of an ankle brace. Using four high-speed video cameras, researchers monitored the subject's ankle position in all three planes of movement. Since the subjects did significantly better when using the ankle brace (as compared with results without the brace), the results of that particular study provided some evidence that a rigid ankle orthosis would help improve this particular aspect of proprioception, at least in a nonweightbearing position. Karlsson and Andreasson,<sup>4</sup> using surface electromyography, investigated the effects of tape on the reaction time of the peroneus longus when the ankle was submitted to a sudden inversion tilt. Their results indicated that the delayed muscular reaction time that was present in patients with chronic ankle instability was markedly improved (although not completely back to normal) with the use of tape. These authors concluded that the increased cutaneous stimulus provided by the tape helped in the earlier recruitment of muscles that could protect against inversion injuries.

The above studies all used ankle taping or bracing as applied to the ankle for sports participation. Because ankle taping also leads to mechanical restriction and mechanical pressure on subcutaneous structures such as tendons and muscles, it is difficult to infer that these results are solely due to increased cutaneous stimuli. The mechanical pressure caused by taping could well influence proprioception and muscular reaction time. In our study, the application of tape to the skin was designed to specifically increase proprioception through cutaneous stimuli without added mechanical stresses on related underlying structures.

The testing apparatus used in our study was initially designed and built by the principal investigator to quantify the

loss of proprioception resulting from distal peripheral diabetic sensory neuropathy.<sup>9</sup> In the current study, the device was used to evaluate joint movement and position perception at the ankle in an attempt to provide some support to the belief that an external cutaneous stimulus, such as that provided by tape applied over the skin, may increase joint proprioception.

Our results appear to support the findings of Feuerbach et al,<sup>17</sup> whose work with ankle orthoses showed that the application of an external support to the ankle improves JPP in a nonweightbearing position. However, while the improvement in JPP occurred for both the dorsiflexed and plantar-flexed angles, it is clear from the data in Table 2 that the effect of taping is particularly marked for the plantar-flexed position. Therefore, taping would provide added proprioceptive information that could possibly help in the proper positioning of the ankle just prior to foot contact during running or just prior to landing when coming down from a jump. In our opinion, this is a significant finding since most ankle sprains occur during the weight acceptance phase, which takes place when running and when landing from jumps. Therefore, an increase in ankle JPP could help in properly positioning the foot and ankle and could possibly help in better detecting an uneven ground or object under the foot that could affect proper foot placement.

While both angular positions that we tested should be considered in the midrange of the ankle joint available range of movement, the difference in effectiveness of the strips of tape between the dorsiflexed and plantar-flexed position can possibly be attributed to the fact that 5° of dorsiflexion is closer to end-range than the 10° of plantar-flexion position. The added effectiveness of the strips of tape in the midportion of the range of movement would theoretically be supported by the documented lesser effectiveness of the joint mechanoreceptors to provide joint position sense in midrange as compared with end-range.<sup>21</sup>

Of particular interest is the fact that no increase in position perception was achieved with the strips of tape in the full weightbearing position. These results again support earlier work that has been done with a functional weightbearing task such as maintaining balance.<sup>5-8,18,19</sup> Therefore, for weightbearing tasks such as maintaining standing balance or the stance phase of walking or running, the cutaneous stimulus from strips of tape as used in this experiment does not appear to be of benefit from a proprioception perspective. However, taping may still be of benefit from the mechanical perspective of restricting excessive movement at the ankle.<sup>22,23</sup>

Our study also demonstrated that athletic tape, as used here on healthy subjects, does not provide any advantages for the detection of joint movement in either weightbearing or non-weightbearing situations.

We conclude from this research that increased cutaneous sensory feedback provided by strips of athletic tape applied across the ankle joint of healthy individuals can help improve ankle JPP in nonweightbearing situations, especially for a midrange plantar-flexed ankle position. The effect of similar strips of tape in improving proprioception in individuals with chronic and acute ankle sprains remains to be established.

## ACKNOWLEDGMENTS

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